

Parallelized carbon oxidation and surface recession model in Direct-simulation Monte Carlo code, SPARTA

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Ablative thermal protection system (TPS) materials for spacecraft are composites that often consist of a carbon-based reinforcement and a polymeric matrix. During Earth re-entry, they endure high-temperature oxidation and surface recession. Oxidation is an important mechanism for ablation, sometimes leading to the weakening, spallation, or failure of the oxidized fibers at the surface and in the char layer [1]. However, more details are required including accurate material properties of the fiber microstructure, whether the fibers recede homogenously or localized at pits, and the role of pyrolysis outgassing in order to evaluate the role oxidation plays in the degradation and failure mechanisms of these materials.

In this work, we demonstrate a parallelizable oxidation-driven [2] ablation model developed for detailed, large-scale simulations in the DSMC code SPARTA [3]. We also develop robust algorithms which handle the conservation of the surface state after an ablation step. Finally, we verify our model for both simple and more complex chemistry as well as microstructures with reaction statistics, oxidation depth calculations, and detailed visualization of oxidation-induced material recession at the microscale.

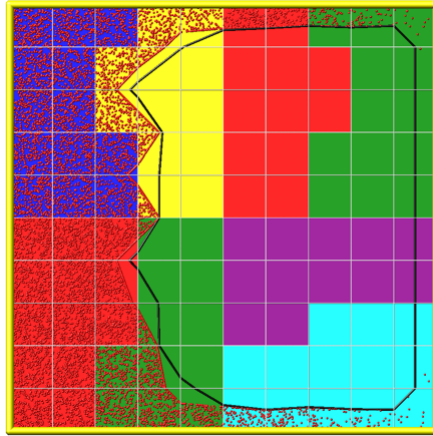


Fig. 1. A simple 2D geometry with gridlines (white), implicit surface (black), particles (red dots), and grid cell regions colored by processor (8 processors in this case).

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